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(54) Over-fire air feeding system

(57) A system for feeding over-fire air to a combustion chamber (10, 24, 42) of a steam or hot water generation plant of low-medium capacity, using solid, liquid or gaseous fuel or a combination thereof, comprising a main combustion air duct (5) supplied to a burner unit (11, 25, 43) in the combustion chamber and an over-fire air duct (12, 27, 44), which extends within said combustion chambers and is provided at its end with nozzle means (17, 27, 47) for said over-fire air.

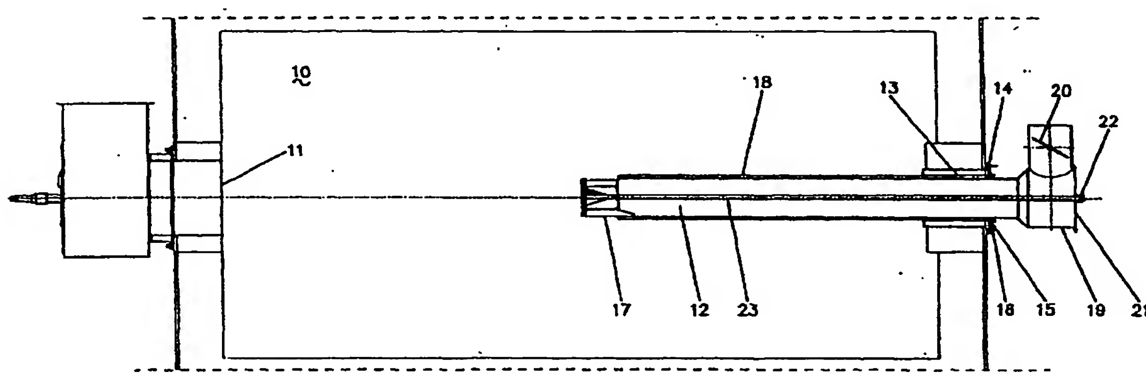

Fig. 2

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Description

[0001] The present invention relates to a simplified system for feeding over-fire air (O.F.A.) designed to be installed on industrial heaters of low-medium capacity, namely lower than 25 MW, apart from the fuel used, with the purpose of keeping the pollutant emissions, in particular nitrogen oxides, as low as possible.

[0002] A widespread technique to reduce the production of nitrogen oxide (NO_x) in the combustion processes occurring in industrial plants and electric power generation plants is that of the so-called step combustion, which consists in suitably dosing the air and fuel within the combustion system, in such a way to form a fuel rich zone in which the fuel pyrolisis processes occur and NO_x reduction processes are activated. This zone is followed by a fuel lean zone, wherein the combustion reaction is completed by mixing the remaining part of the combustion air with the fuel. In practice, by reducing the oxygen availability in the primary flame zone the speed of formation of nitrogen oxides both from the fixation of the atmospheric nitrogen (thermal NO_x) and from the oxidation of the nitrogen contained in the fuel (chemical NO_x) is inhibited. Due to the reduced presence of the oxygen the nitrogen present in the fuel is forced to recombine with other nitrogen, thus forming molecular nitrogen, N_2, instead of nitrogen oxide. Similarly, due to the lower temperatures which are reached, lower combustion temperature peaks occur thereby reducing the formation of the thermal NO_x.

[0003] A way of putting into practice the step combustion technique is that described in European Patent No. 0452608, according to which combustion air is subdivided into three streams, namely primary air, secondary air and tertiary air, which are supplied to the combustion chamber near the burner outlet coaxially to the fuel inlet. Another way of putting into practice the step combustion is that according to the OFA technique which consists in diverting a portion of the combustion air from the burners to over-fire air ports placed over-fire on the furnace wall downstream of the burner and introducing the portion of combustion air into the furnace through these ports. The amount of diverted combustion air is controlled so that the ignition combustion of the fuel occurs at substoichiometric condition to create a reducing atmosphere which minimizes the formation of nitrous oxides. The over-fire air supply system varies according to the embodiments and often comprises air injectors, swirling vanes, separate blowers and other associated equipment, resulting in installations that are complex and expensive.

[0004] In order to comply with the more and more stringent regulations regarding the reduction of pollutant emissions and in particular nitrous oxide (NO_x) emissions, the retrofitting of the existing plants is necessary. This may involve structural modification to the furnace or additional exhaust gas treatment plants (for example, the so-called DeNO_x plants). In the case of plants for the production of hot water or steam of low-medium capacity, the above mentioned alternatives are both unfeasible both for technical and cost reasons.

[0005] In particular, if a step combustion according to the OFA technique would be used to reduce the NO_x emissions, openings would have to be formed in the part under pressure of the furnace to create the over-fire air supplying ports, which would give rise to many serious problems.

[0006] The object of the present invention is to provide a system for supplying the over-fire air to a furnace of low-medium capacity for hot water or steam generation characterized by a low construction cost, in particular if applied to the retrofitting of existing plants.

[0007] According to the invention the system for supplying the over-fire air to a furnace for the generation of hot water or steam comprises a over-fire air duct extending within the combustion chamber in such a way to provide the over-fire air injection from a rear wall of the furnace with respect to that where the burner is placed, or sidewise with respect to the same wall through an existing opening, for example a manhole, or a dedicated opening, formed in a not pressurized part of the furnace, for example through the refractory material.

[0008] If the over-fire air is injected from the rear wall, the injection is performed through a suitable nozzle which can be coaxial to the burner, if the furnace is equipped with only one burner, or coaxial to the burner assembly, if the furnace is equipped with more than one burner. In the case of a side injection, the nozzles for supplying the over-fire air are arranged near the sidewalls of the furnace, generally near the floor.

[0009] Features and advantages of the over-fire air supplying system for industrial furnaces according to the present invention will become apparent from the following description of exemplifying, non-limiting embodiments thereof made with reference to the attached drawings wherein:

- Figure 1 schematically shows a furnace with relevant supplying system of the main combustion air and of the over-fire air according to the prior art;
- Figure 2 shows a system for rear injecting the over-fire air according to the invention;
- Figure 3 shows a system for sidewise injecting the over-fire air according to the invention;
- Figures 4 and 5 show two different nozzles for injecting over-fire air in a rear injection system;
- Figures 6 and 7 show two different supplying systems for sidewise injecting the over-fire air according to the invention.

[0010] The diagram shown in Figure 1 represents the conventional solution for supplying the combustion air to an industrial furnace, generally indicated at 1, wherein the combustion air is divided into two streams, one of which is supplied to the burners together with the fuel and the other is directly supplied to the upper part of the

furnace as over-fire air. Burners 2, arranged in one or more arrays, are connected to the relevant conduits 3 and 4 for feeding the fuel and, respectively, for feeding the main combustion air. Ducts 4 branch from a main air header 5 coming from a heat recovery unit 6, for example a Ljungstrom, in countercurrent to the combustion exhaust gas 7 directed to the stack. The combustion air is supplied by blower means 8 located upstream of the furnace. A certain amount of the combustion air is sucked by a fan 9 from combustion air duct 5 downstream of heat recovery unit 6 to be supplied to the upper part of the furnace, indicated at 1a, to complete the combustion. The inlet of the over-fire air in the combustion chamber is achieved through a series of ports formed on the furnace wall.

[0011] The overall flow rate of the combustion air, the flowrate of the air supplied to the single burners, the flowrate of air drawn as over-fire air as well as that of the air admitted through the single supply ports are controllable within large ranges by means of suitable air locks as schematically shown in figure 1.

[0012] In figure 2 there is shown, in a longitudinal cross-section, a system for the rear injection of the over-fire air according to the present invention. With reference to this figure, there has been indicated at 10 a combustion chamber and generally at 11 a burner or a burner assembly, for example a group of two or four burners. An over-fire air injection device 12 extends within the combustion chamber coaxially to the burner from a nozzle 13 located on the rear wall of the furnace through an adjustment device, comprising a flange 14, a counterflance 15 and a gasket 16, through which the protrusion of injection device 12 within the combustion chamber can be regulated so as to allow the axial movement of an injection nozzle 17 mounted at the free end of injection device 12. Injection device 12 is lined with a layer of insulating material 18. At the outer side of combustion chamber 10 injection device 12 is connected to an air inlet 19 possibly equipped with a control air lock 20 and a closure flange 21 with a handle 22 extending therefrom for clamping a rod for moving nozzle 17, in the case of mobile nozzles.

[0013] A system for over-fire air supply with side injection is shown in figure 3. In this figure the combustion chamber has been indicated generally at 24 and 25 indicates a generic burner or burner assembly. Located at the front wall of the furnace, in particular below burner 25, is a nozzle 26 within which a side over-fire air duct 27 extending in combustion chamber 24 is placed. Duct 27 ends with an injection duct 28 transversally arranged to the combustion air flow and equipped with a plurality of tubular nozzles 29 having circular, square or rectangular cross-section. Outside of combustion chamber 24 duct 27 is connected to an air inlet 30 possibly equipped with an adjustable air lock 31 for the over-fire air.

[0014] As a function of the design needs injection duct 28 may extend also along the side walls, taking a U-shaped configuration and the injection nozzles 29 may be replaced by a narrow slit extending along injection duct 28 in such a way to supply the over-fire air to the furnace in the form of a continuous laminar barrier instead of discrete jets.

[0015] Nozzles of the conventional type, which can be used for supplying the over-fire air to the combustion chamber in the case of rear injection of the over-fire air, are shown in figures 4 and 5. The nozzle shown in figure 4 provides a continuous radial outlet for the over-fire air and comprises a bottom plate 32 lined with insulating material 33 from which a connection system 34 of rod 23 for moving the nozzle extends. The nozzle is equipped with a plurality of fixing plates 35 for mechanical strengthening and a plurality of blades 36 arranged outside of the nozzle to convey the over-fire air.

[0016] The nozzle shown in figure 5 provides a radial outlet in the form of jets for the over-fire air and comprises a bottom plate 37 lined with insulating material 38 from which a connection system 39 of rod 23 for moving the nozzle extends. The nozzle is provided with a plurality of fixing plates 40 for mechanical strengthening and a plurality of diverting blades 41 arranged in the outer side of the nozzle to direct the over-fire air outlet.

[0017] Figures 6 and 7 show other side injection modes for the over-fire air as in the case of figure 3, but with an air supply coaxial to the burner and in particular rear coaxial supply (figure 6) and front coaxial supply (figure 7). In the case of figure 6, in which 42 and 43 generally indicate a combustion chamber and, respectively, a burner or burner assembly, an over-fire air supply duct 44 is introduced in the furnace through a manhole 45 and then extends vertically down to the floor and finally runs longitudinally thereon, in particular over the tube bundle. Duct 44 ends with a transverse injection duct 26 bearing tubular injection nozzles 47. The solution of figure 7, on the other hand, can be adopted when a manhole or another opening in a suitable position are unavailable or when the solution of figure 3 cannot be adopted. In this case the air supply duct is formed around burner 43 and extends therefrom within the combustion chamber in the same way as shown in figure 6.

[0018] Advantageously, in order to further reduce the smoke point of the exhaust gas discharged from the stack, a part of the exhaust gas coming from the furnace, in a percentage not higher than 15%, may be recirculated. It can be injected in the overall combustion air stream, in the air supplied to the burners only, in the over-fire air only or even in one of the burner conduits.

[0019] With respect to the systems of supplying and injecting over-fire air according to the prior art, the system of the invention allows the same typical step combustion to be carried out with the same level of reduction of NO_x (up to about 200 mg/Nm^3) by means of a structurally simple solution for low-medium capacity steam and hot water generators and in particular it makes the OFA technique applicable to existing generators of the above mentioned type without requiring modifications of the pressurized parts of the furnace, as existing access-

es to the combustion chamber may be used.

[0020] Variations and modifications can be brought to the over-fire air supply system according to the present invention, without departing from the scope of the invention as set forth in the appended claims.

Claims

1. A system for feeding over-fire air to a combustion chamber (10, 24, 42) of a steam or hot water generation plant of low-medium capacity, using solid, liquid or gaseous fuel or a combination thereof, comprising a main combustion air duct (5) supplied to a burner unit (11, 25, 43) in said combustion chamber and an over-fire air duct (12, 27, 44), **characterized in that** said over-fire air duct (12, 27, 44) extends within said combustion chamber and is provided at its end with nozzle means (17, 27, 47) for said over-fire air.

2. Over-fire air feeding system according to claim 1, wherein said over-fire air duct (12) extends within said combustion chamber coaxially to said burner unit (11) from a wall opposite thereto and ends with a nozzle (17) for radially injecting the over-fire air in said combustion chamber.

3. Over-fire air feeding system according to claim 2, wherein said nozzle (17) in axially sliding.

4. Over-fire air feeding system according to claims 2 or 3, wherein said radial over-fire air outlet is continuous.

5. Over-fire air feeding system according to claims 2 or 3, wherein said radial over-fire air outlet are air jets.

6. Over-fire air feeding system according to any of the claims 2 to 5, wherein said over-fire air duct (12) adjustably extends within said combustion chamber (10).

7. Over-fire air feeding system according to claim 1, wherein said nozzle means (29, 47) for the over-fire air are located close to the side walls of said combustion chamber (24, 42) and are arranged on an injection duct (28, 46) crosswise extending within said combustion chamber and communicating with said over-fire air duct (27, 44).

8. Over-fire air feeding system according to claim 7, wherein said nozzle means (29, 47) are equally spaced tubular nozzles.

9. Over-fire feeding system according to claim 7, wherein said nozzle means are formed by a continuous slit along said injection duct (28, 46).

10. Over-fire air feeding system according to any of claims 7 to 9, wherein said over-fire air duct (27, 44) is entered said combustion chamber (24, 42) through a manhole (45).

11. Over-fire air feeding system according to any of claims 7 to 9, wherein said over-fire air duct (27, 44) is entered said combustion chamber (24, 42) through an opening formed in a not-pressurized part of the generator.

12. Over-fire air feeding system according to any of claims 7 to 9, wherein said over-fire air duct (44) is entered said combustion chamber (42) coaxially to said burner unit (43).

13. Over-fire air feeding system according to anyone of the previous claims, wherein a portion of the exhaust gas is added either to the overall combustion air flow or to the air supplied to all or some of the burners or to the over-fire air flow only.

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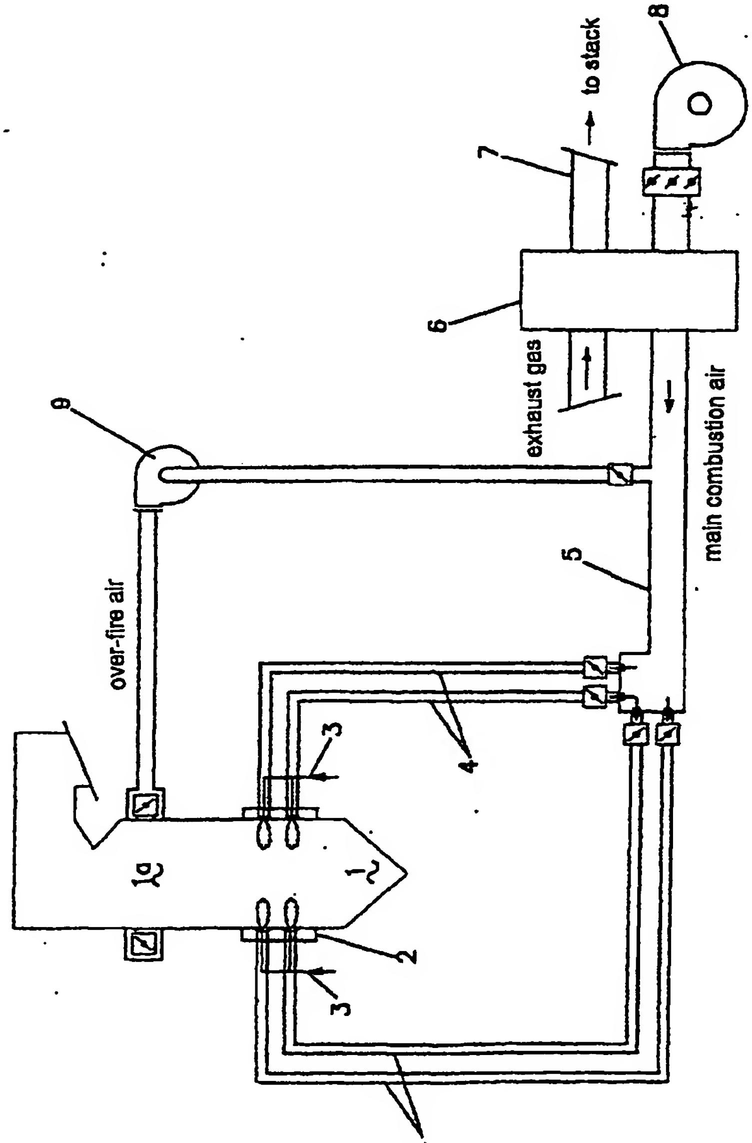

Fig. 1

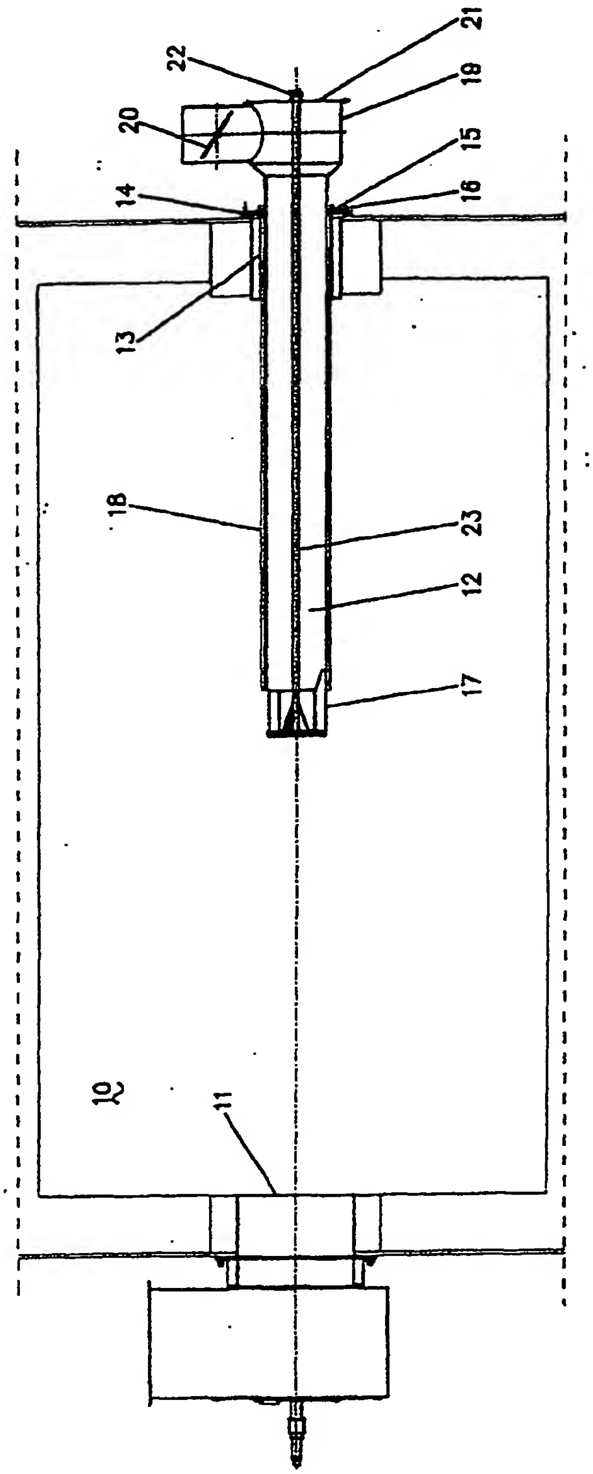

Fig. 2

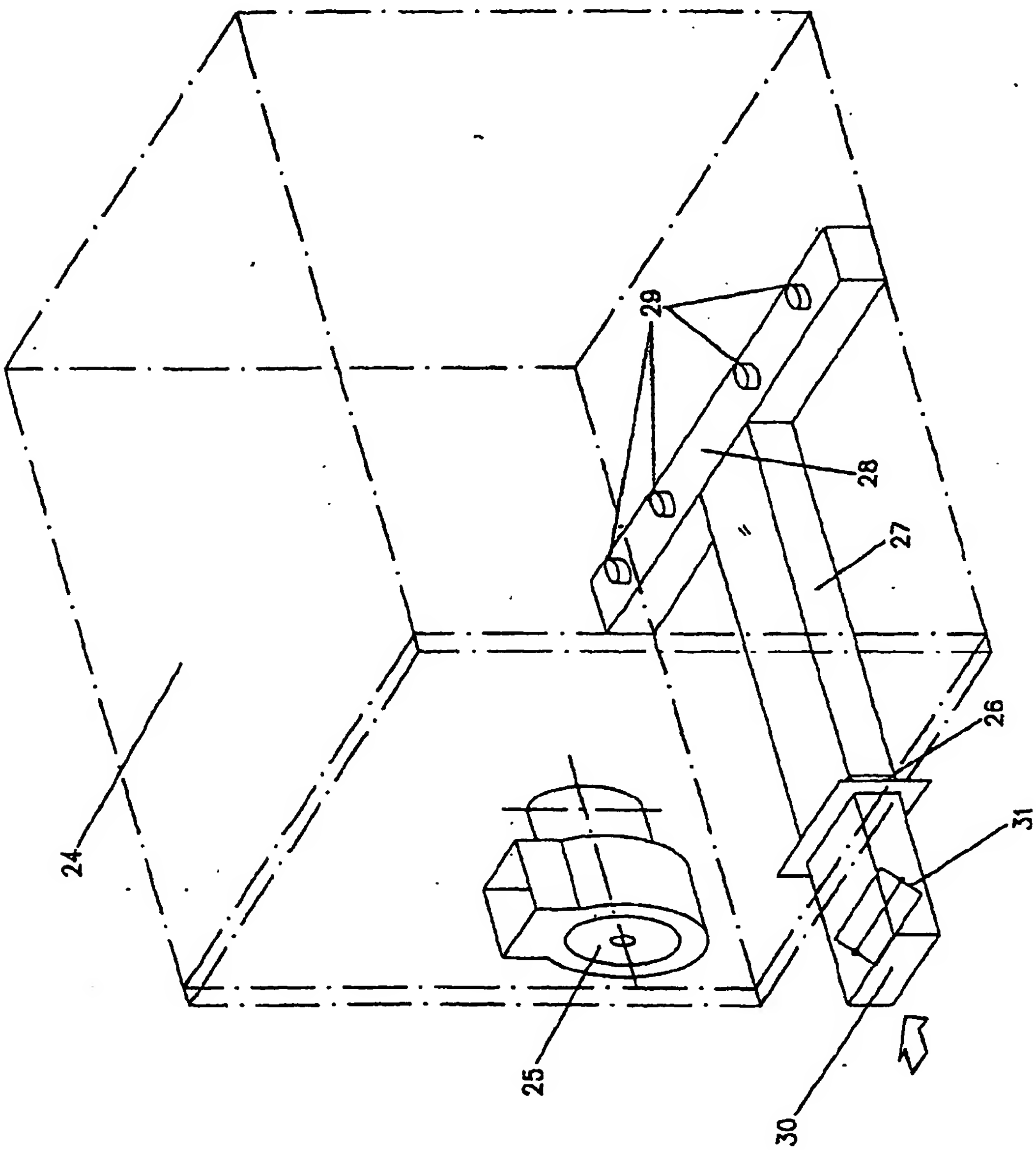

Fig. 3

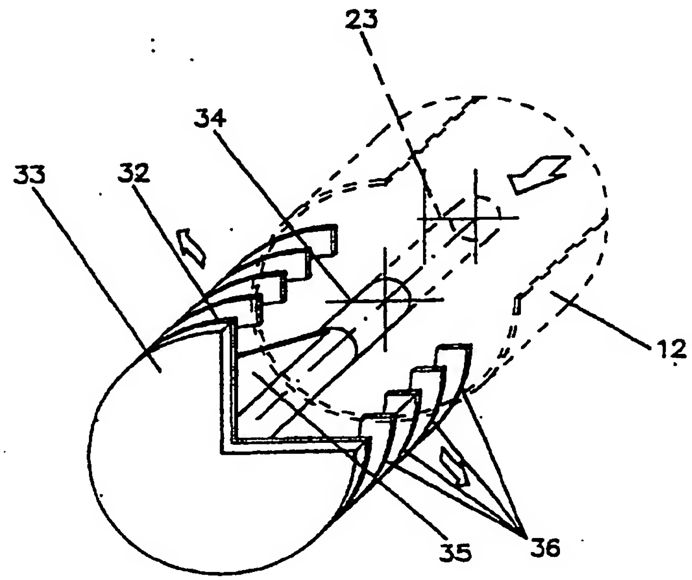

Fig. 4

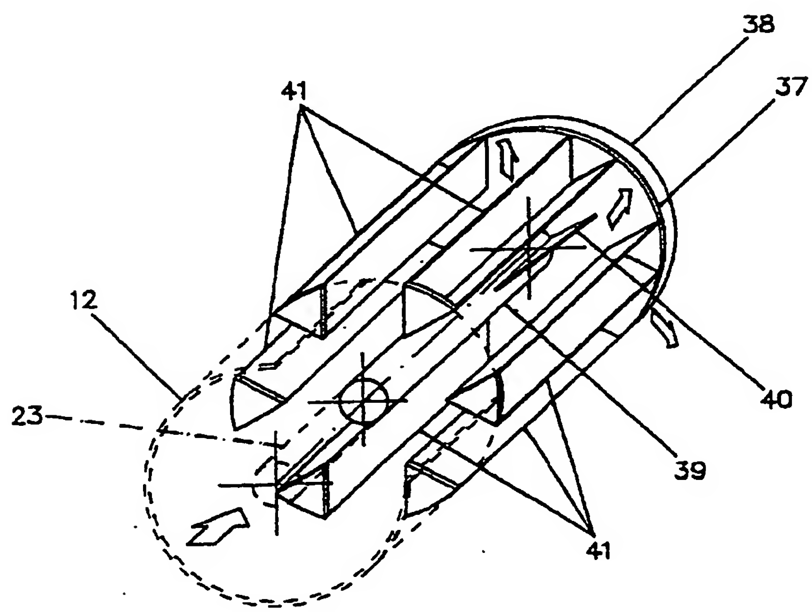

Fig. 5

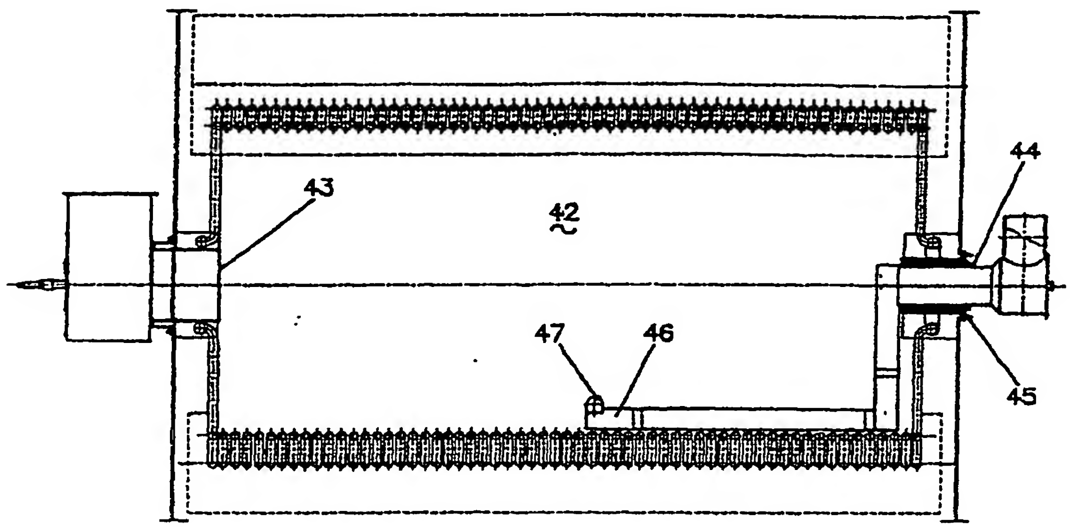

Fig. 6

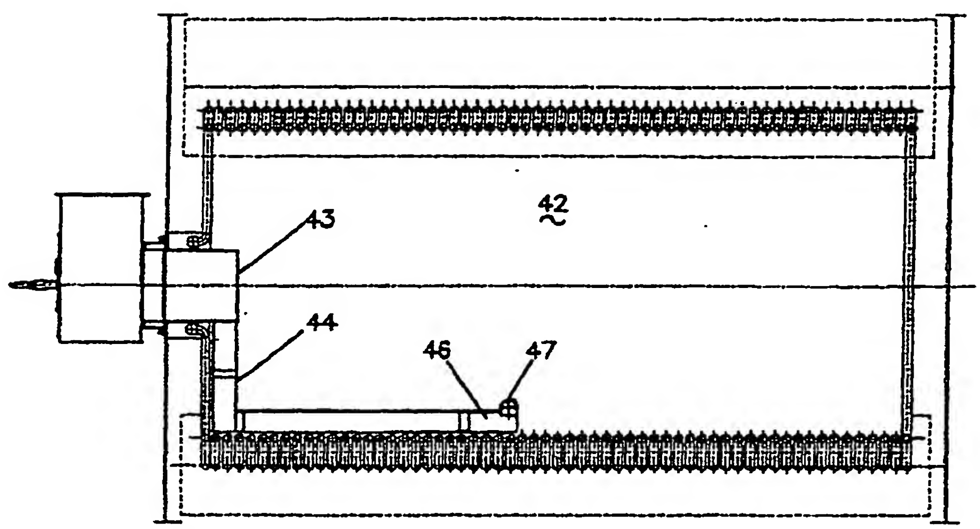

Fig. 7

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Application Number
EP 01 83 0704

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	28 February 2002	Mougey, M

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